Multi-technique characterization of arsenic ultra shallow junctions in silicon within the ANNA consortium.

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ABSTRACT

The ongoing size reduction of silicon CMOS devices has required the development of processes able to create ultra shallow junctions in order to match the specifications for source and drain extensions. The latter demand very steep dopant distributions confined in the first 10-20 nm of the substrate. The characterization of those distributions is known to be extremely challenging. For instance, secondary ion mass spectrometry (SIMS) has been often used to determine the chemical depth distribution of dopant in Si, due to its high dynamic range and sensitivity, excellent depth resolution and good reproducibility. However, matrix effects and initial transient width hinder the accuracy of the technique when applied to distributions close to the surface. Furthermore, the early formation of roughness and different sputtering rates between surface SiO_2 and the Si substrate may distort the depth calibration and resolution. Therefore a complementary analytical approach is desirable if critical information like retained dopant dose, junction depth and junction abruptness have to be evaluated. In this work results obtained within the EC financed ANNA project (Analytical Network for Nanotechnology, co. n. 026134(RII3)) in which one of the activities is related to the characterization of ultra shallow distributions of As in Si, will be summarized. A matrix of samples has been prepared by ion implantation in order to test the capabilities of the different analytical techniques represented within the consortium. As^+ implant energy varied between 0.5 and 5.0 keV whereas the doses were between 5×10^{14} and 5×10^{15} cm^{-2}. These samples were then characterized by SIMS, grazing incidence x-ray fluorescence spectroscopy (GIXRF), soft x-ray GIXRF using synchrotron radiation, tilted sample high angle annular dark field scanning transmission microscopy (HAADF-STEM), neutron activation analysis (NAA), spectroscopic ellipsometry (SE) and medium energy ion scattering (MEIS). Cross comparison of the dose measurements, 'near-surface' dopant distribution and damage build-up behavior have enabled a detailed characterization of these implanted samples. They have also identified the overlap in information gained from the different analytical techniques present in our consortium.

Keywords: ultra shallow junctions, arsenic, silicon.